A Possible Relation between the Occurrence of a Dendritic Organ and the Distribution of the Plotosidae (Cypriniformes)

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ABSTRACT: Three marine species of Plotosidae are found along the coastlines of the Indian and Pacific oceans, but the other 25 species occur exclusively in the Australian region. The majority of the Plotosidae are freshwater inhabitants, some of which are indigenous to both Australia and New Guinea. The marine members of the family and two freshwater members possess a dendritic organ. It is suggested that this organ has an osmoregulatory function.

IN THEIR DESCRIPTION of the catfish *Plotosus anguillaris*, Bloch (1794) and LaCépède (1803) mention the presence of a peculiar external structure situated posterior to the vent and between the pelvic fins. Cuvier and Valenciennes (1840) observed that this structure had no connection with the urogenital system, but was attached to the last abdominal vertebra by means of a long tendon. According to Brock (1887) and Hirota (1895) this so-called dendritic organ consists of numerous well-vascularized epithelial folds. Weber and de Beaufort (1913), Taylor (1964), and Munro (1966) used the presence of this organ as a criterion in their keys to the family Plotosidae. However, apart from its use in taxonomy this structure has attracted very little attention.

Recently, electron microscope studies by van Lennep and Lanzing (1966) have shown that the dendritic organ of *Plotosus anguillaris* (Bloch), *Cnidoglanis macrocephalus* (Val.), and *Euristhmus lepturus* (Gunther) possesses two main cell types: principal cells containing parallel groups of cytoplasmic tubules and many mitochondria, and clear cells containing an unusual three-dimensional network of cytoplasmic tubules. Because of a similarity between these cells and those occurring in salt glands of sharks and marine birds and the chloride cells in fish gills, the authors suggested that the plotosid dendritic organ is involved in salt transport. This assumption has led to a study of a possible relation between the occurrence of a dendritic organ and the distribution of the Plotosidae in marine and freshwater environments.

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DISTRIBUTION OF THE SILUROIDEI

The siluroids of the Austral-Asian region are best represented in the area bounded by Thailand, Vietnam, and Indonesia. The following families occur in this region: Akysidae, Amblycipitidae, Bagridae, Chacidae, Clariidae, Heteropneustidae, Plotosidae, Schilbeidae, Siluridae, Sisoridae (Bagariidae), and Tachysuridae (Ariidae). Except for the Tachysuridae and three species of Plotosidae none of these catfish are found east of the line of Wallace. In the Australian region, which includes Australia, New Guinea, and some adjacent islands (Darlington, 1957), only the Doiichthyidae, Plotosidae, and Tachysuridae occur.

DISTRIBUTION OF THE PLOTOSIDAE

All known species of Plotosidae are inhabitants of the Australian region, but three marine species have a much wider range (Fig. 1). *Paraplotosus albilabris* (C. et V.) occurs in Indonesia, Vietnam, and the Philippines (Suvatti, 1950; Herre, 1953; Kuronema, 1961). *Plotosus canius* Ham. Buch. is reported from East Africa as well as from Fiji (Fowler, 1959), but does not seem to occur in China or Japan. On account of its wide range it is surprising that it has not yet been reported from Australia, although it is present in New Guinea (Munro, 1958). *Plotosus anguillaris* (Bloch) is distributed over a vast area. The western

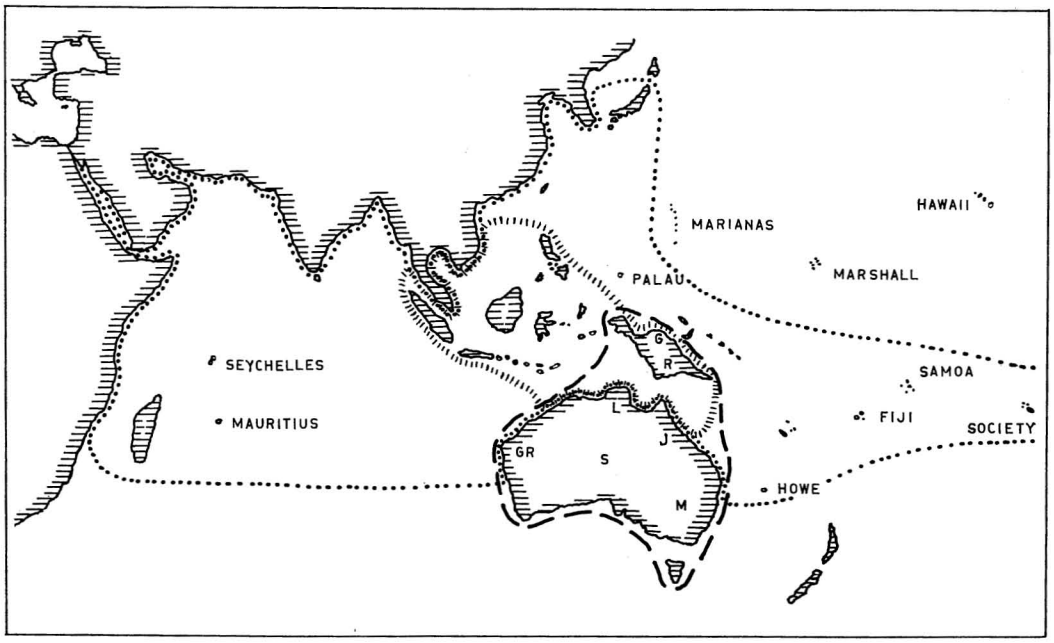

FIG. 1. Distribution of the Plotosidae. ——, Principal range of the Plotosidae; . . . , range of *Plotosus anguillaris;* / / /, range of *Paraplotosus albilabris*. For letter symbols see footnote for Table 1.

limit of its range is formed by the Southwest Asiatic Barrier (Ekman, 1953), as it has been found in the Red Sea and the Suez canal (Fowler, 1956). Although present along the East African coast, it does not reach Cape Town (Smith, 1949). It occurs in Korea (Mori, 1952) and Japan (Okada, 1955) as well as in the Society Islands; the Eastern Pacific Barrier (Ekman, 1953) apparently forms the eastern limit of its range. *Plotosus anguillaris* is not recorded from the Marshall and Marianas Islands (Schulz, 1953), which ichthyologically are more related to the Hawaiian region.

The distribution of the other plotosids, however, is strictly limited to the Australian region. Of the marine plotosids only *Cnidoglanis macrocephalus* is found all along the coast of mainland Australia, Tasmania, and New Guinea; the other marine species occur only in the northern half of Australia and in New Guinea. Most of the freshwater plotosids are indigenous to the Leichhardtian fluvifaunula (see map by Whitley, 1959), although *Tandanus tandanus* Mitchell, for instance, is confined to the Mitchellian fluvifaunula. Table 1 shows that several freshwater plotosids are common to both Australia and New Guinea (e.g., *Porochilus obbesi* Weber). Other species are exclusively New Guinean, e.g., *Neosilurus gjellerupi* (Weber), or Australian, e.g., *Tandanus tandanus*. Munro (1964) recently drew attention to the existence of differences between the ichthyological fauna of northern New Guinea (Gaimardian fluvifaunula) and that of southern New Guinea (Riechian fluvifaunula). Apparently, some plotosids like *Neosilurus gjellerupi* and *N. ater sepikensis* (Whitley) live in the Gaimardian area, whereas *N. brevidorsalis* (Gunther) and *N. ater ater* (Perugia) are confined to the Riechian area.

THE PRESENCE OF A DENDRITIC ORGAN AMONG THE PLOTOSIDAE

Table 1 lists two groups of Plotosidae: the species in group A possess a dendritic organ, whereas this organ is lacking in the plotosids of group B. The species of group A occupy a marine or estuarine habitat, but thus far *Oloplotosus mariae* Weber and *Plotosus papuensis* Weber have been found only in fresh water

TABLE 1

DISTRIBUTION AND HABITATS OF THE PLOTOSIDAE*

SPECIES	AUSTRALIA	NEW GUINEA	HABITAT
Group A (dendritic organ present)			
1. *Cnidoglanis macrocephalus* (Val.)	+	+	marine
2. *C. microceps* (Rich.)	+	—	marine
3. *C. muelleri* (Klunzer)	+	—	marine
4. *Euristhmus lepturus* (Gunther)	+	+	marine
5. *E. nudiceps* (Gunther)	+	+	marine
6. *Oloplotosus mariae* Weber	—	+ R	fresh water
7. *Paraplotosus albilabris* (Val.)	+	+	marine
8. *Plotosus anguillaris* (Bloch)	+	+	marine
9. *P. canius* Ham. Buch.	—	+	marine
10. *P. papuensis* Weber	—	+ R	fresh water
Group B (no dendritic organ)			
1. *Anodontiglanis dahli* Rendahl	+ L	—	fresh water
2. *Neosilurus argenteus* (Zietz)	+ S	—	fresh water
3. *N. ater ater* (Perugia)	+ L	+ R	fresh water
N. ater sepikensis (Whitley)	—	+ G	fresh water
4. *N. bartoni* Regan	—	+ R	fresh water
5. *N. brevidorsalis* (Gunther)	+ L, J	+ R	fresh water
6. *N. equinus* (Weber)	—	+ R	fresh water
7. *N. gjellerupi* (Weber)	—	+ G	fresh water
8. *N. glencoensis* (Rendahl)	+ L	—	fresh water
9. *N. hyrtlii* Steindachner	+ L, J	—	fresh water
10. *N. idenburgi* (Nichols)	—	+ G	fresh water
11. *N. meraukensis* (Weber)	—	+ R	fresh water
12. *N. mortoni* Whitley	+ L	—	fresh water
13. *N. novaeguineae niger* (Nichols)	—	+ G	fresh water
N. novaeguineae novaeguineae (Weber)	—	+ R	fresh water
14. *N. perugiae* (Ogilby)	—	+ R	fresh water
15. *N. rendahli* (Whitley)	+ L	—	fresh water
16. *Porochilus obbesi* Weber	+ L	+ R	fresh water
17. *Tandanus bostocki* Whitley	+ Gr	—	fresh water
18. *T. tandanus* Mitchell	+ M	—	fresh water

* Symbols used: +, present; —, absent; G, Gaimardian fluvifaunula; Gr, Greyian; J, Jardinian; L, Leichhardtian; M, Mitchellian; R, Riechian; S, Sturtian.

(Weber and de Beaufort, 1913). All the species of group B are freshwater inhabitants.

Examinations carried out on adult and juvenile individuals of *Plotosus anguillaris, Cnidoglanis macrocephalus,* and *Euristhmus lepturus* showed that the dendritic organ is present and equally developed in both sexes, and also that it is already conspicuous in juvenile catfish ranging in size between 45 and 56 mm. Recently, van Lennep (unpublished) found that, in comparison with adults, the dendritic organ of juvenile catfish contains only a relatively small number of fully developed glandular cells.

The mean length of nine adult *Plotosus anguillaris* was 322 mm (286–361 mm) total length. Since some of the gonads were either in a fully mature or in a spent condition, these measurements must represent the size of adult catfish of this species. Comparable figures have been reported by Delsman and Hardenberg (1934), 300 mm; Okada (1955), 250 mm; and Fowler (1959), 460 mm. A much higher figure for maximum size (30 inches) is given by Smith (1949), and is quoted by Munro (1954) and Fowler (1956), but probably is erroneous.

DISCUSSION

More than half of the 28 species of Plotosidae are freshwater inhabitants. This makes

the Plotosidae a predominantly freshwater family rather than a chiefly marine family, as is often implied in the literature (Berg, 1957; Darlington, 1957; Nikolsky, 1961; Sterba, 1963).

It appears that 25 species are found in the Australian region. Three marine species occupy a much larger area covering most of the Indian and West Pacific oceans. Sterba's map (1963) of the distribution of the Plotosidae therefore actually shows the range of one species, namely *Plotosus anguillaris*. It is of interest that among the non-plotosid siluroids only *Tachysurus thallasinus* (Rueppel) has a range as wide as that of *Plotosus canius*, except that the former is also reported from Japan (Matsubara, 1955).

As yet no physiological work has been carried out with regard to the function of the dendritic organ. The available evidence indicates that: (a) its structure resembles that of salt-secreting glands in other vertebrates, (b) it is present in both juvenile and adult plotosids, (c) there exist no sexual differences, and (d) it is not present in freshwater plotosids other than *Oloplotosus mariae* and *Plotosus papuensis*. Hardenberg and Delsman (1934) suggested that the dendritic organ is involved in reproduction, but produced no evidence in support of this claim. A possible respiratory function merits consideration since other catfish (Clariidae, Heteropneustidae) possess accessory respiratory organs. These, however, are in connection with the branchial chambers and are structurally different from the dendritic organ. Furthermore, there seems to be no reason why only marine plotosids should require an accessory respiratory organ. Both marine and freshwater plotosids enter muddy environments that could contain oxygen-deficient water. A salt-excretory function seems to be the most likely, although, admittedly, the presence of a dendritic organ in *Oloplotosus mariae* and *Plotosus papuensis* does not fit in with this theory. Too little is known about these two species to venture any explanation.

According to Darlington (1957:46) marine plotosids may have invaded the Australian region and, after entering a freshwater habitat, reached the end of a complicated line of teleost evolution.

Although evolutionary aspects of zoogeography must remain speculative, it is suggested that the dendritic organ was developed while plotosid ancestors in the Southeast Asian region invaded the sea. This invasion would be different from that of the Tachysuridae, which were able to cope with osmotic stresses by means of mechanisms similar to those used by other old teleost families, such as the Salmonidae. Perhaps because of tachysurid competition, the plotosid ancestors became firmly settled only in the Australian region. From them would have evolved, on the one hand, the freshwater species which lost the dendritic organ in the process. Some of the marine species, on the other hand, managed to disperse radially along the edges of the Indian and West Pacific ocean basins.

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REFERENCES

BERG, L. S. 1957. Classification of Fishes Both Recent and Fossil. Edward Bros. Ann Arbor, Michigan.

BLOCH, M. E. 1794. Naturgeschichte der Auslandischen Fische, vol. 8. Schlesinger, Berlin.

BROCK, J. 1887. Über Anhangsgebilde des Urogenitalapparates von Knochenfische. Z. wissen. Zool. 45:532.

CUVIER, G., and A. VALENCIENNES. 1840. Histoire Naturelle des Poissons. XV. Levrault, Paris.

DARLINGTON, P. J. 1957. Zoogeography. The Geographical Distribution of Animals. John Wiley & Sons, New York.

DELSMAN, H. C., and J. D. F. HARDENBERG. 1934. De Indische Zeevissen en Zeevisscherij. Visser and Co., Batavia.

EKMAN, S. 1953. Zoogeography of the Sea. Sidgwick and Jackson, London.

FOWLER, H. W. 1934. The fishes of Oceania, Suppl. 2. Mem. B. P. Bishop Mus. 10(6). Honolulu.

——— 1938*a*. The Fishes of the George Vanderbilt South Pacific Expedition. Acad. Nat. Sci. Philadelphia, Monogr. 2.

——— 1938*b*. A List of Fishes Known from Malaya. Fish. Bull. 1. Govt. Printing Office, Singapore.

——— 1956. The Fishes of the Red Sea and Southern Arabia. Vol. 1. Weizmann Sci. Press, Jerusalem.

——— 1959. Fishes of Fiji. Govt. Fiji Publ., Suva.

HERRE, A. W. 1953. Checklist of Philippine Fishes. U.S. Fish Wildl. Serv. Res. Rept. 20.

HIROTA, S. 1895. On the dendritic appendage of the urogenital papilla of *Plotosus anguillaris*. J. Coll. Sci. Imp. Univ. Japan 8:367.

KURONEMA, K. 1961. A Checklist of Fishes of Vietnam. Div. Agric. Nat. Resources, U. S. Operations Miss. Vietnam.

LACEPEDE, B. G. E. 1803. Histoire Naturelle des Poissons. V. Plassan, Paris.

LENNEP, E. W. VAN, and W. J. R. LANZING. 1967. The ultrastructure of glandular cells in the external dendritic organ of some marine catfishes. J. Ultrastr. Res. (In press.)

MATSUBARA, K. 1955. Fish Morphology and Hierarchy. Ishizaki-Shoten, Tokyo.

MORI, T. 1952. Check list of the fishes of Korea. Mem. Hyogo Univ. Agric. 1:228.

MUNRO, I. S. R. 1957. Handbook of Australian fishes, No. 10. Fish. News Letter 16(4):41.

——— 1958. The fishes of the New Guinea region. Papua and New Guinea Agric. J. 10(4):97.

——— 1964. Additions to the fish fauna of New Guinea. Papua and New Guinea Agric. J. 16(4):141.

——— 1966. Fishes of New Guinea. (In press.)

NIKOLSKY, G. V. 1961. Special Ichthyology. Israel Program. Sci. Transl., Jerusalem.

NORMAN, J. R. 1951. A History of Fishes. Ernest Benn, London.

OKADA, Y. 1955. Fishes of Japan. Maruzen, Tokyo.

SCHULZ, L. P., ET AL. 1960. Fishes of the Marshall and Marianas Islands. Vols. I and II. Smithsonian Inst., U. S. Natl. Mus. Bull. 202.

SMITH, J. L. B. 1949. The Sea Fishes of Southern Africa. Central News Agency, Cape Town, South Africa.

STERBA, G. 1963. Freshwater Fishes of the World. Vista Books, London.

SUVATTI, C. 1950. Fauna of Thailand. Dept. Fish., Bangkok.

TAYLOR, W. R. 1964. Records of the American-Australian Expedition to Arnhemland. Vol. 4, Zoology. Melbourne Univ. Press.

WEBER, M., and L. F. DE BEAUFORT. 1913. The Fishes of the Indo-Australian Archipelago. II. Brill, Leiden.

WHITLEY, G. P. 1959. The freshwater fishes of Australia. In: Ed. Keast, et al., Biogeography and Ecology in Australia. Junk, The Hague.